Experimental Framework for Mobility Anchor Point Selection Scheme in Hierarchical Mobile IPv6

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Abstract—**Hierarchical Mobile IPv6 (HMIPv6) was designed to support IP micro-mobility management in the next generation Internet Protocol (IPv6) and the Next Generation Networks (NGN) framework. The general idea behind this protocol is the usage of Mobility Anchor Point (MAP) located at any level router of network to support hierarchical mobility management and seamless handover. Further, the distance MAP selection in HMIPv6 causes MAP overloaded and increase frequent binding update as the network grows. Therefore, to address the issue in designing MAP selection scheme, we propose an enhance distance scheme with a dynamic load control mechanism (DMS-DLC). From the experimental results we obtain that the proposed scheme gives better distribution in MAP load and increase handover speed. In addition a new proposed research framework was established that uses the four stages model.**

Index Terms— **HMIPv6, Mobility Anchor Point, MAP selection scheme, speed detection, dynamic load control, Next Generation Networks**

I. Introduction

The Next Generation Networks (NGN) is expected to provide seamless handover in very high speed wireless network environment. There is crucial needed of very sophisticated protocols to support NGN QoS requirements. The Internet Engineering Task Force (IETF) has developed IP version 6 (IPv6) to anticipate address space and internet growth. In IPv6 protocol, the Mobility Header is identified by a Next Header value in IPv6 Header. Therefore IPv6 need a mobility support to ensure packets destined to a mobile node (MN) is reachable while it is away from its home address [1].

Mobile IPv6 (MIPv6) allow transparent routing of IPv6 packets to MNs. Although it supports mobility, it has problems on supporting seamless handover due to high delay. Every time MN move to new access router, it acquires new Care-of Address (CoA) and must notify Binding Update (BU) to Home Agent(HA) and Correspondent Node (CN) for each handover. Hierarchical Mobile IPv6 (HMIPv6) [2] is based on MIPv6 which aims to reduce the signalling amount between the MN, its CNs and, its HA. By utilising a new node called Mobility Anchor Point (MAP), it can improve the handover speed. As shown in Fig. 1 the MAP can be located at any level in a hierarchical network of routers so that the MN can send local binding update to the local MAP rather than the HA. Therefore the furthest MAP selection in HMIPv6 can be a MAP overload and increase frequent binding update

problem as the network grows. It is only suitable for fast MNs that will perform frequent handoffs because the MNs reduce the changing of MAPs. Hence, without specific an efficient MAP selection scheme can affect the system performance and supporting seamless handover.

This paper proposes a new MAP selection scheme by MN operation in HMIPv6 using the designed experimental framework. The new scheme is proposed to reduce the BU delay and to achieve the network performance. Besides, we also improve the distance-based enhanced with speed detection to achieve dynamic MAP load control management in HMIPv6.
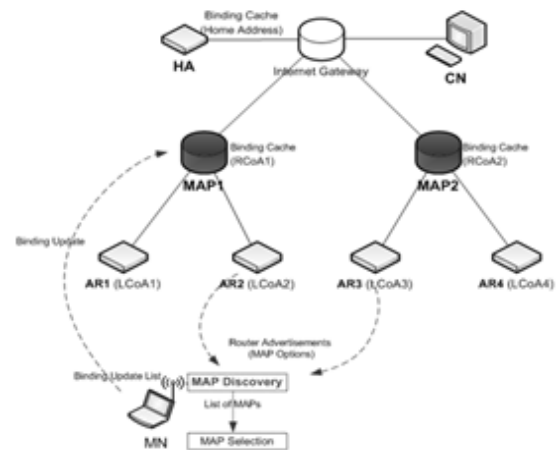

Figure 1. HMIPv6 Operations

II. Methodology

The methodologies of this research use the theoretical study and experimental research and developed in four main stages, including theoretical study, analysis and modelling, implementation and evaluation.

A. Proposed research framework

From the methodology, a new research framework is established as shown in Fig.2. The research framework builds on this new perspective focus on theoretical study and experimental study. It describes the six processes of proposing distance-based MAP selection scheme with Dynamic Load Control (DMS-DLC) and used throughout this research. The experimental study consists of analysis and modelling, implementation and evaluation. Central to this research framework is data validation connected to all processes in the experimental study module.

(1) Theoretical study

The research on the MAP selection scheme was generated from a comprehensive theoretical study which involved reviewing and analyzing the current state of art and all related works, problems and issues pertaining on map selection schemes from different approaches and using different technologies.

(2) Analysis and Modelling

We suggest a model that integrates load control mechanism to any MAP selection scheme. By this model can support modularity in designing the MAP selection scheme in HMIPv6 in adapting load control mechanism and MN's speed detection.

(3) Implementation

The MAP selection scheme suite as well as HMIPv6 extensions to MIPv6 were developed an extension to OMNET ++ xMIPv6 suite [15] and OMNET++ 4.0 [13] network simulator. The emulated model was used to conduct experiments in environments where it was not possible to set up real network or test bed.

(4) Evaluation

This paper evaluates the performance of the DMS-DLC scheme in the context of MAP selection . The scenario was designed by the reason of IPv6 deployment challenges especially for the implementation in the real world scenario.
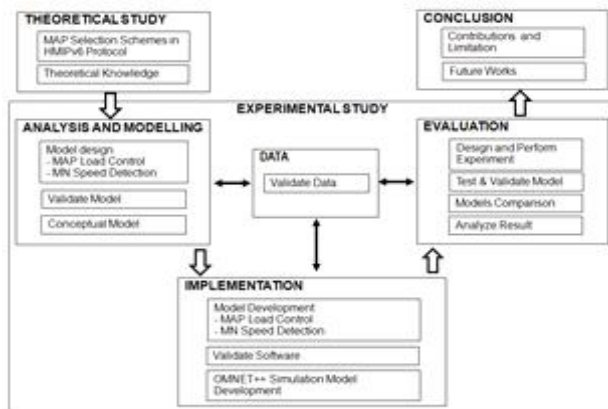

Figure 2. Experimental Framework

B. Model validation

The MAP selection scheme proposed in this work is validated using Sargent Framework [14] for model evaluation. The limited assessment selected for the methodology is constrained by time and resources and it may not possible to investigate the entire model in even these limited areas. Technical processes for limited assessment emphasized in a limited application are conceptual model validity, model implementation verification and operational testing.

III. RELATED WORKS

A. Hierarchical Mobile IPv6 (HMIPv6)

The design of MIPv6 does not attempt to solve all general problems related to the use of MNs or wireless networks. Specifically this protocol does not solve local or hierarchical forms of mobility management [1]. Since MIPv6 only support global mobility, a hierarchical scheme that separates micro-mobility from macro-mobility is preferable. In HMIPv6 the usage of a new node, MAP can be used to improve the performance of Mobile IPv6 in terms of handover speed. An MAP is essentially a local HA situated in the foreign network as shown in Fig.1. It can be located at any level in a hierarchical network of routers so that it can be classified as a micro-mobility.

MAP Discovery should choose to use HMIPv6 implementation if the MN is HMIPv6-aware. Besides the uses of MAP in HMIPv6, an MN will also have to configure two new types CoAs: a regional care-of-address (RCoA) and an on-link care-of-address (LCoA). The LCoA is a local address to the MN received from Access Router (AR). The RCoA is an address on the MAP's subnet, configured when an MN received a Router Advertisement (RA) message with the MAP Option during MAP Discovery [3]. The MAP performs the function of a "local" HA that binds the MN's RCoA to an LCoA. After an MN get new RCoA and LCoA addresses then it sends a Local Binding Update (LBU) to the MAP in order to establish a binding between the RCoA and LCoA.

B. MAP Selection Scheme

In HMIPv6, a distance-based selection [2] was proposed where an MN may choose the furthest top most MAP in the hierarchy in order to avoid frequent re-registrations. Numerous researches have been carried out to deal with these issues such as mobility-based, adaptive-based, dynamic-based and also load control [4] [5] [6] [7]. While mobility and adaptive looked similar in nature, the main difference is mobility consider the MN's criteria, the adaptive approach took the MAP's criteria. In general, it is difficult to measure the MN's characteristic such as velocity and mobility rate hence the measurements are often inaccurate. Furthermore, that characteristic cannot be considered by the MAP.

C. MAP Load Control Mechanism

In load control mechanism [8] introduced a load balancing mobility management by average BU interval in both AR and MN is adopted. When the interval of sending BUs in MN is shorter than that of receiving BUs in AR, the MN selects a MAP with largest distance because the MN's movement is estimated to be fast. If the interval of sending BUs in MN is longer than that of receiving BUS in AR, the MH selects a MAP with the second largest distance. To keep the transparency to HMIPv6, this average BU interval in AR is mapped into the 4-bit binary preference value in the MAP option. In another MAP load control mechanism [9], the MAP Load Table (MLT) was designed to record the load condition of neighbor MAPs. When the MN receives the MLT, it will choose the MAP which has minimum load value to register. The scheme takes the MN's particular characteristics which include the mobility velocity and quantity of communication services.

D. Velocity-based (Speed) Mechanism

In [9] [10] there are two main steps: the measurement of the MN's velocity or speed and the selection of MAP to

register with.The issue is how to measure the MN's speed because it is difficult to calculate the precise value of the speed. Only when the MN's speed is estimated and then the MN can select suitable MAP by the MAP Table (MT) that records the mapping relation between the MN and related MAP. Algorithms based on the speed of an MN, measured in handovers per unit time, were suggested in [10]. Faster MNs select more distant MAPs, as it is believed that faster movement leads to a larger moving area. Then, the estimated speed of the MT can be also obtained by dividing the distance that the MT has traversed in the previous access area by the dwell time. In LV-MAP and DV-MAP [11] schemes the MN select an optimal MAP and the furthest MAP supporting MN's velocity, with the aim to reduce the frequency of inter-domain handovers. The MN may need sophisticated algorithms to select the appropriate MAP and its speed as an input combined with the preference field (load control value) in the MAP option during RA.

IV. DMS-DLC SCHEME

A. Dynamic MAP Load Control Algorithm

We model the scheme with the incorporate dynamic MAP load control algorithm in HMIPv6 networks. We then quantify the impact of the redistribute the MAP load on the communications performances. In particular, we utilize the binding update process to the selected MAP during the MAP discovery process and the load control value that equivalent to MN number that connected to the MAP. The current load and preference value are given as:

$$Current\ load = number\ of\ MAP\ Binding\ Cache \qquad (1)$$

$$Preference = (1-(current\ load\ /\ threshold\ value))*15 \qquad (2)$$

From (2), the current load is inversely proportioned preference value. In this selection scheme the process will select the nearest MAP with highest preference where the maximum value is 15 in the MAP option.

B. MN's Speed Detection Algorithm

We also suggest a model that detects the speed of the MN. The process starts with the determination of the first location to the MN's next location. The speed of the MN will be calculated by the MN with the distance value divides by the time taken during the movement between locations. The process for the speed detection can also be done during the handover of the MN to the new MAP. The MNs can select the furthest and nearest MAPs by according to their speed. The fastest MNs select the most distant MAPs and vice versa. The MN also can also change the scheme dynamically whenever the speed is changed so it will reduce frequent BU. We provide detailed descriptions of possible usages of MN speed detection along with the coordinate in the particular network topology. This protocol based on HMIPV6 Distance Based MAP Selection Scheme delivers mobility service to whole networks, such as MN moving in different speed (fast or slow), and to standard IPv6 nodes that do implement HMIPv6 on the client side.

$$Distance_n^2 = (x_n - x_{n-1})^2 + (y_n - y_{n-1})^2 \qquad (3)$$

$$Time_n = t_n - t_{n-1} \qquad (4)$$

where x_2 and y_2 are the coordinate of MN's new location and $x_1 - y_1$ are the coordinate of MN's previous location while t_n and t_{n-1} are destination time and arrival time.

The total of overall distance of the MN can be measured with the sum of all movement from 0 to n:

$$total\ distance = \sum_{n-1}^{\infty} \sqrt{((x_n - x_{n-1})^2 + (y_n - y_{n-1})^2)} \qquad (5)$$

From (4) and (5) then the speed in second(s) of MN can be derived:

$$speed_n = (distance_n\ /\ time_n)\ mps \qquad (6)$$

$$average\ speed(n) = \sum_{n=0}^{n} \left(\frac{speed_n}{time_n}\right)\ /\ n \qquad (7)$$

Fig. 3 shows an example the distance between the previous and the new MAP of an MN movement.
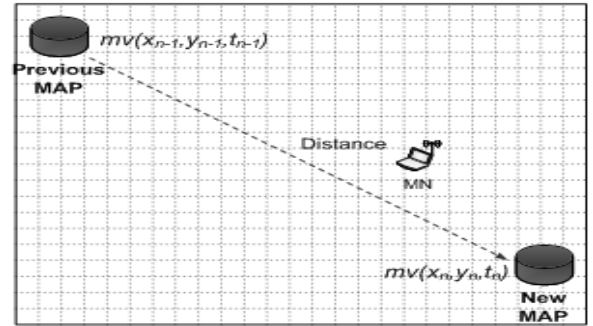

Figure 3. MN movement

The MN speed probably changes every time it registers to new MAP. The speed detection algorithm in Fig. 4 will determine the MN speed derived from the distance and time of each movement or after receiving successful binding acknowledgement (BA). It can dynamically change the nearest or furthest scheme depending of the current average speed.

```
MAIN( )
Begin
    If MN is "HMIP6-aware" then
        MAP Discovery ( )
        MN receive (MAP_ID, MAP Options, MAP Domain)
        Speed_Detection(Distance Scheme )
        MAP_Selection (DMS-DLC, Distance Scheme).
    End if
End
Procedure Speed_Detection(Distance Scheme )
Begin
    Record the new location,  new arrival  time After receive
      successful BA from MAP
    Calculate the MN's speed
    Define the speed of MN whether slow or fast
End
If  speed = fast then return (Furthest MAP)
   elseif speed = slow  then return(Nearest MAP)
End if
```

Figure 4. Speed Detection Algorithm

V. PERFORMANCE ANALYSIS

A. Experimental Setup

In the simulation model, the wireless diameter is within the range 200 m with simulation area is 2000×1250 meter². The total of ten MNs are communicated with the CNs through several of speed from slow to fast movement as shown in Fig. 5. The traffics are running on ping applications with 56 Bytes data and 5 seconds interval time. The wireless access network is based on the IEEE 802.11b and WLAN standard with a free space channel model. The propagation delay between the MN, the MAP, the HA and the CNs is assumed negligible. For the evaluation purpose we simulate three performance metrics: load condition of each level MAP, binding update list and ping round-trip time (RTT) by each MN. Besides, the proposed method will also be compared with the other methods: distance-based and dynamic-based.
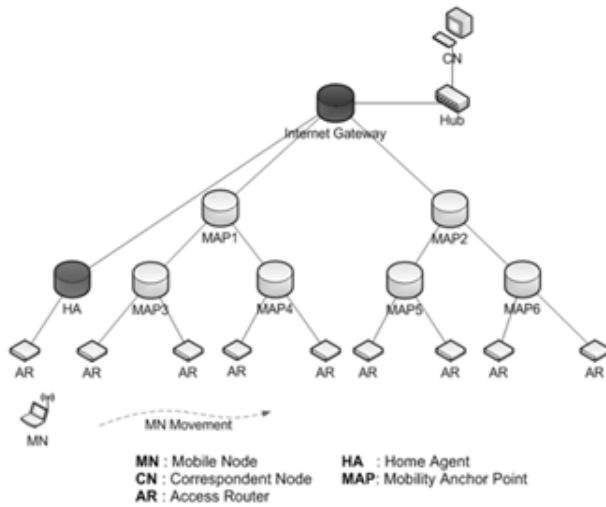

Figure 5. Network scenario

B. Results and Discussion

Fig. 6 shows the load distribution of each MAP by four different schemes. In this measurement MAP binding cache is indicating the performance of MAP load control mechanism. A MAP binding cache is a "MAP registration" entries or a database (similar to a routing table) that contains the mappings between RCoA and LCoA. By comparing load for leach level of MAP where for the furthest MAP reduce with 49.02% and for the nearest MAP reduce to 45.50%. Although the total binding cache of proposed scheme is higher than the furthest, it supports the best distribution of MAP load. Fig. 7 illustrates the performance of MN's binding update list between four different schemes. It is obvious to discover that the proposed scheme can reduce the MNs' total binding update list and better than the nearest and dynamic scheme. Especially in the best case with slow MNs move within the same domain, it is still superior because the proposed scheme possibly let each MN choose the suitable MAP which efficiently reduces the binding update cost. Fig. 8 shows that the ping RTT rates differ in the four schemes and changing of packet size is less influence the result. It discovers that the proposed scheme can reduce the signal time for sending

packet amongst the compared schemes. The DMS-DLC performs better than both schemes and lowest ping RTT rate among the other schemes. In general the selection with furthest MAPs will affect the rate of high ping RTT.
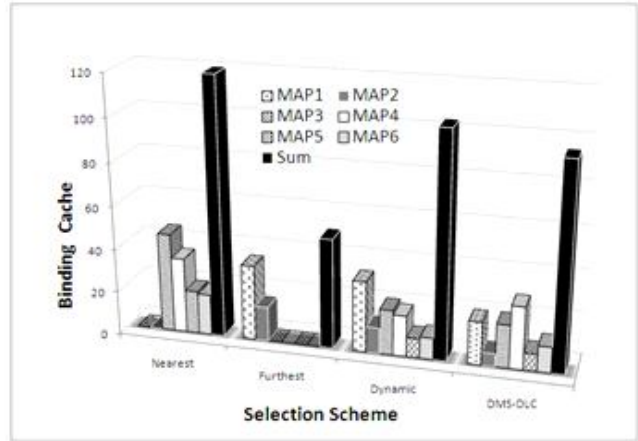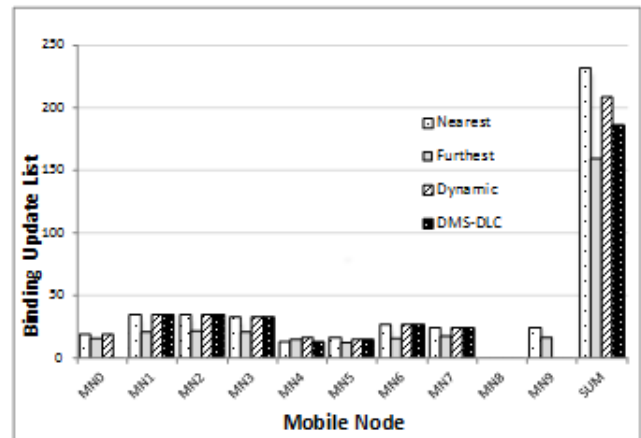

Figure 6. Load Comparison between MAPs
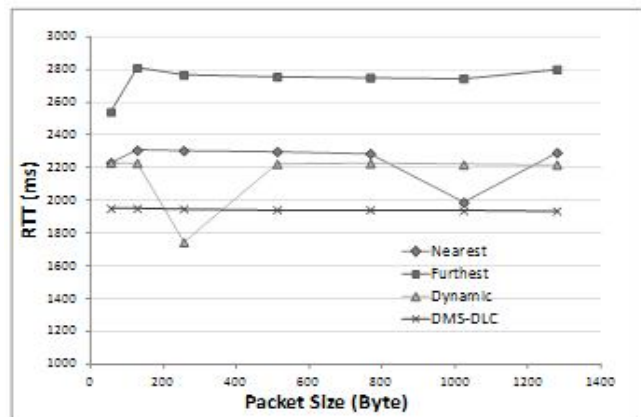

Figure 7. Total MN's binding update list

Figure 8. MN's Ping RTT vs packet size

VII. CONCLUSIONS

In summary, the research methodology in this paper describes the steps taken in conducting this research. The research began with the theoretical study followed by conducting several preliminary studies based on simulations of the selected methods. The results generated were analyzed

using standard performance measures in the map selection scheme approach. In this study, we discussed and proposed the speed mechanism adapted in HMIPv6 MAP selection scheme. The load control was also measured based on MN and MAP properties. From the experimental results shows that our proposed scheme gives better distribution in MAP load and reduces binding update cost. In evaluating the performance based on ping RTT, result showed positive prediction for dataset where the DMS-DLC is found to be significantly better than other schemes.

Further work should be carried out in determining MAP load characteristics, its type and how to minimize re-frequent binding cache of the MAP. This might be on the account of the various MNs' speeds with multiple MAP selection schemes. The model can be dynamically change and chose the scheme depending on the MN's mobility or MAP's attributes. There is crucial needed of very sophisticated mobility protocols to support NGN QoS requirements and seamless handover. HMIPv6 protocol is one that will be support the NGN technology development for IP micro-mobility or Localized Mobility Management [12].

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